

Review on Virtual Reality for the Advancement of Architectural Learning

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Abstract—A set of virtual reality (VR) based learning environment is being produced to investigate the possibilities for technological innovations and to discover where and how VR may best assist architecture instructors. VR has been utilized as an instructional aid in education, challenging the idea of what makes a learning environment more effective. Thanks to HD (high-definition) visuals and comprehensive contents given by head mounted displays (HMD), learners have been able to study complex and difficult subjects in ways that conventional teaching approach cannot. This paper reviews several learning domains that advance architectural education to benefit the scholars and academicians for usage of immersive VR technologies and its application to design studio. Research on learning benefits, intervention and evaluation action related to the usage of Virtual reality has been lacking. This literature review stresses that it is necessary for the VR's potential to be understood as a pedagogical approach by identifying relevant evaluation methods, intervention features and learning objectives.

Keywords— Virtual Reality (VR); Architectural education; Head mounted display (HMD); Immersive Learning Domains; VR technologies

I. INTRODUCTION

VR is termed as a 3-D computer-based interactive environment that model's reality. However, the origin of the word virtual reality is unknown. It has been attributed to Damien Broderick's 1982 novel The Judas Mandala, where the context of use differs from what is stated currently [1]. Virtual Reality (VR) is also described as the use of computer simulations and models to assist a person in engaging with a 3D world that is artificial. This 3D virtual environment depicts reality with the use of interactive devices that may transmit and receive data and are worn in the form of headsets, goggles, gloves, or body suits, among other things. Virtual reality, in other terms, is the use of computer animation to mimic physical presence in the virtual environment and to create a realistic-looking world. Virtual reality is interactive and real-time technology, which implies that the device is designed to automatically recognise human input and alter the virtual environment in real time [2]. The traditional method of teaching reveals flaws in the teaching plan and learning processes of architecture. Teaching and learning techniques are often instructor-independent at many colleges that can overcome by using VR.

VR has three distinguishing features as a medium [1]. It is:

- 1) Immersive; users may interact with the models;

- 2) Three spatial dimensions are used to represent spatial models; and
- 3) Real-time response from activities is provided without a notable pause.

VR may be categorized based on the methods of visualization that it employs:

- 1) Immersive Virtual reality with a high level of involvement and expensive peripheral equipment, such as HMDs; and
- 2) Non-immersive Virtual reality, also known as desktop VR, is a doorway into a virtual environment that is presented on a computer screen [3].

Blended reality has been characterized as an immersive mixed environment in which the virtual and physical worlds are intimately integrated to serve interaction objectives and communication settings [4].

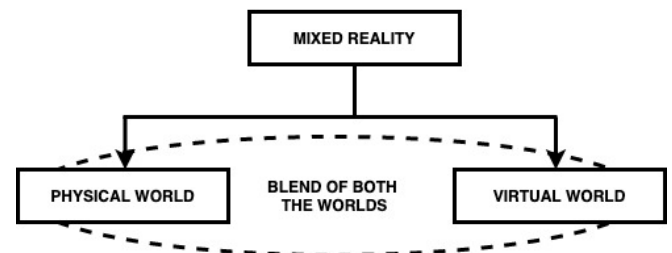


Fig. 1. Mixed reality

Fig.1 shows how the increased realism and increased virtuality on the physical-virtual continuum are positioned in mixed reality. Using this technology increases interest in studying the given subject, becoming a facilitator of educational factor that leads to the development of capable students, opens possibilities, and is encouraged to invest in technology, and supports its implementation in the class [5-9].

The primary focus of this paper has been focused on Bloom's Taxonomy's Domains of Learning [10-14]. Bloom's taxonomy is a collection of 3 hierarchical frameworks used to categorize educational learning outcomes according to their specificity and complexity that are cognitive [15-39], physiological skills [40-43] and affective [44-48] learning domains.

The possibilities of VR have been demonstrated, but it needs to be seen how and also where such capabilities may be

effectively utilized to architecture education. As a result, this paper will go through several learning domains that may be used in architectural education. This research will be beneficial to scholars and academicians as it will lead to more research into the usage of immersive VR technologies.

There are six sections in this paper: Section II discusses the VR devices. Section III and IV states the relationship between hypotheses and research design and also review the various methods and learning domains. Section V consists of conclusion.

II. VR TECHNOLOGY DEVICES

Recent research [6] demonstrate the potential provided by such technological developments, since they enable an unique type of reality in which digital and physical surroundings, multimedia, and connections coexist in our daily lives. The usage of immersive experience platforms, in addition, has started to be employed in the educational and professional sectors, since it enables people to be near to that same reproduced area while allowing a quick flow of design modifications performed in actual environments [7]. Devices which are used in VR technologies are shown in Fig.2.

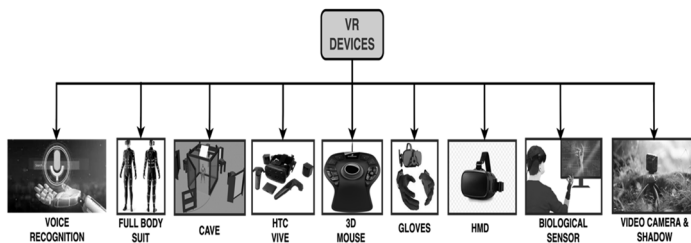


Fig. 2. Devices used in VR technologies

Analyzing and interpreting 3D environments has traditionally been done via sketches, drawings, illustrations and object models rather than 3D scale models and virtual representations all across the existence of architectural education [8]. Because of intergenerational transition and the continual growth and advancement in technology, worldwide adoption of such new approaches is on the rise [9].

III. RELATIONSHIP BETWEEN HYPOTHESES AND RESEARCH DESIGN

In particular instructional instruments, the issue in finding the learning domains to meet competence standards can be highlighted as the primary focus of the study. It shows that a number of variables have an influence on student progress, including education methods, tasks and technology instruments. The best way of addressing this problem is to assess different approaches, analyze all elements of it and select the most practical tool for adequate skill development in the learning procedure. The main purpose of the study is to compare how Virtual reality education varies in terms of understanding architecture from the traditional classroom.

As a result, three hypotheses are proposed:

Hypotheses_1: In a basic architecture curriculum, the Virtual Reality class enhances and develops fundamental competencies more than the traditional class;

Hypotheses_2: In a basic architecture curriculum, the Virtual Reality class doesn't really increase or build key competencies any faster than the traditional class;

Hypotheses_3: In a basic architecture curriculum, the Virtual reality class helps to develop just a limited set of skills.

The primary focus of this work has been focused on Bloom's Taxonomy's Domains of Learning [10]. Bloom's taxonomy is the collection of three sequential frameworks for categorizing learning process outcomes according to their specificity and complexity. The 3 lists include cognitive, affective, and physiological motor skills learning domains as displayed in Fig.3.

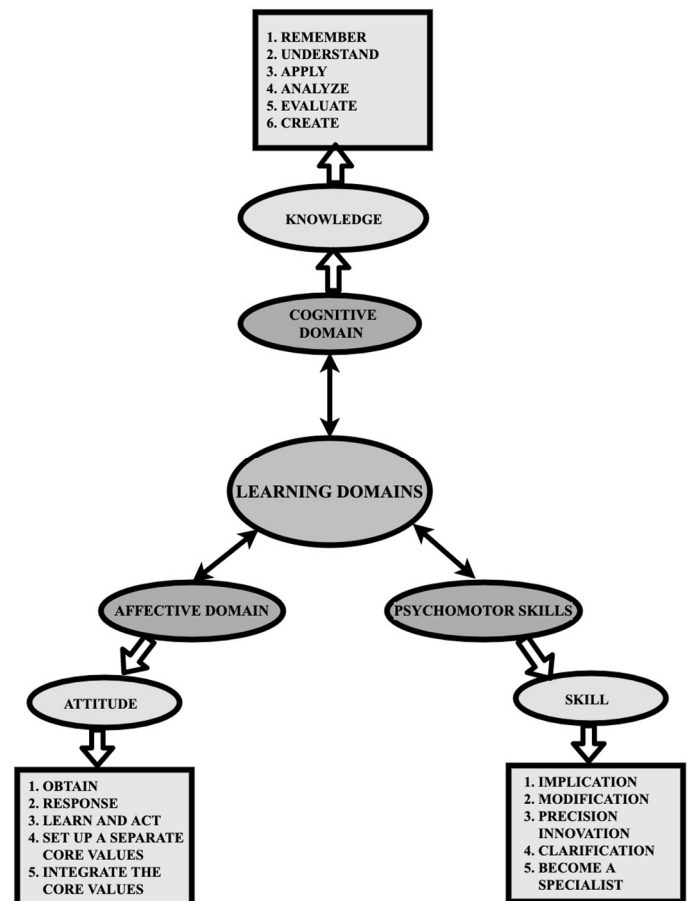


Fig. 3. Classification of Learning Domains

A. Cognitive Domain

Cognitive domain [12-35] seeks to improve an individual's mental abilities and knowledge acquisition. Most conventional education has focused on cognitive domain taxonomy, which is commonly used to create curriculum learning outcomes, evaluations, and activities. The cognitive domain of learning is split into 6 tiers of goals in the original 1956 edition of taxonomy [45].

B. Psychomotor Skill Domain

Psychomotor skill [36-39] is the capacity to manually operate an instrument / tool, such as hammer or hand. Change

and/or growth in behaviour and/or abilities are often the focus of psychomotor skill objectives. Perception, set, directed reaction, mechanisms, complicated observable reaction, adaptability, and genesis are all subdomains of psychomotor. The capacity to adapt sensory input to motor action is referred to as perception [46].

C. Affective Domain

Affective domain [40-44] are usually concerned with increasing awareness and progress in attitudes, emotions, and feelings. Receiving phenomena, reacting to phenomena, valuation, organizing, and characterization are examples of emotional domain categories. Receiving phenomenon is a subdomain that produces awareness of emotions and feelings as well as the potential to use selective attention [47]. This might involve paying attention in class or during group discussion is the next component of replying to phenomena [48].

IV. ANALYSIS OF VARIOUS LEARNING DOMAINS

Several research papers related to VR are reviewed. The analysis of various learning domains including devices used, variables for comparison and their findings have been tabulated in Table I.

TABLE I. REVIEW ON VR LEARNING DOMAINS

Learning Domains	Devices Used	Variable for Comparison	Findings
Cognitive Domain	Oculus headsets [12]	Desktop / Smartphone	Students' developed the ability to examine the 'anatomy' of the structural foundations of the chosen typical 3D building simulation.
	Other [13]	3D Physical Model	I-VR-designed architectural environments receive a higher rating than real models.
	Oculus Rift [14]	Traditional methods	In comparison to traditional teaching approaches, I-VR has been presented to yield considerably greater engineering subject attainment. Furthermore, an HMD-based system outperformed a CAVE-based system.
	Google Cardboard [15]	SlideShow Lecture	All who acquired computer programming via I-VR outperformed than those who were not over the course of 16 sessions.
	Sony HMZ [16]	Lecture	When compared to a lecture, I-VR yielded considerably higher exam

			results.
Samsung Head Gear [17]	Desktop VR		When utilising I-VR for a knowledge exam, the results are poorer.
Oculus Rift [18]	Online Textbook		At the before-test, after-test, and 8 weeks of followup, there was no improvement in test scores.
Oculus Rift [19]	No I-VR (lectures only)		The individuals fared much worse than the control group before the intervention.
Oculus Rift [20]	Desktop VR		Almost both D-VR and I-VR were shown to be incredibly viable learning modality on an anatomical skill test.
VR Samsung Gear [21]	2D Video		There is no variation in knowledge acquisition between both the mediums.
Oculus Rift [22]	Desktop VR Ball-and-stick method		I-VR was never more effective at teaching astronomy over D-VR or traditional approach display.
Samsung Gear VR [23]	Desktop VR		Those who studied geography with I-VR showed significantly superior educational outcomes and moderate memory than others who studied geography with D-VR.
HTC Vive [24]	Textbook 2D Video		The I-VR group did greater than the traditional group in memorizing questions, but there was no difference in grasping questions.
HTC Vive [25]	Desktop VR (tablet based)		Despite the fact that I-VR and D-VR had the same exam scores, I-VR was shown to improve skill acquisition.
HTC Vive [26]	Talk, Hands-on participation in a serious game		A conventional lecture generated a lower exam score than I-VR.
HTC Vive [27]	Traditional didactic teaching		In anatomical and chemistry examinations, I-VR was proven to yield considerably higher academic achievements than individuals who did not utilise the technology.
HTC Vive [28]	Slideshow		On a microbiology test, I-VR students performed considerably worse than

			others who learnt via a standard PowerPoint presentation.
	HTC Vive [29]	Instructor lesson	I-VR was never more successful than an instructor-led class in 6 from out 7 cases.
	Mobile VR [30]	Lecturers and lab sessions	When comparing to the few who studied through lecture and laboratory sessions, individuals who have used the I-VR interface scored considerably better on measures.
	Mobile VR [31]	Desktop VR	Participants who utilised I-VR had better spatial abilities than others who used D-VR.
	HTC System [32]	2D system	In I-VR, especially in comparison to 2D, single session performed slower.
	Oculus Rift [33]	No I-VR (lectures only)	Students who participated in I-VR session performed higher on the final exam papers than most who did not.
	Head Mounted Display (HMD) [34]	Independent study	The ability to see these updates in real time enables designers to conduct an iterative process of parallel programming and visualisation of the model that was created in VR, thereby improving the project.
	Geo VR [35]	Desktop VR	Designers can use various projections, such as top view and birds eye view, to monitor design options and arrive at a final solution.
Psycho motor skills	Oculus Rift [36]	Desktop VR	When compared to D-VR, the I-VR condition completed the functional analysis task much faster.
	Oculus Rift [37]	No I-VR (written material only)	In the Multiple Choice Questions exam, there was no significant differentiation.
	VR Apps [38]	Desktop	Assist in integrating visual and other behaviors within the educational process in order to link the new learnt materials with students' previous experiences and knowledge
	AR apps or	Mobile Phone	VR enables organisations and academic institutions

		gadgets. [39]	to not only discuss theories, but also the practical implications of theories and novel concepts in an interactive manner, while also remaining at the forefront of technology.
Affective Domain	Oculus Rift DK1 [40]	Stereoscopic desktop VR	In psychiatric discussion training, both virtual and non-virtual modalities achieved equivalent outcomes.
	NVIS nVisor SX60 [41]	3-D room with a threat	In this paper experiment group felt sensations as they felt the explosions, spiders, gunshots, etc.)
	Oculus Rift DK2 [42]	3D fire evacuation	In this paper students went Alertness while going through fire evacuation.
	Samsung Gear VR [43]	3D rooms	Positive affect can be seen in this case.
	HTC Vive [44]	3-D art museum	Real museums vs 3-D art museums were compared among the two groups. The general validity of environmental simulations is rather high.

V. CONCLUSION

This paper reviews the significance of VR for the advancement of teaching and learning in architecture which will be advantageous to scholars and academicians. According to the recent findings, VR is an effective educational tool for extremely complicated or conceptual issues that needed visualisation and spatial comprehension. The usage of VR in architecture broadens the function of studio evaluations to become more collaborative and interactive. The purpose of this review was to discover which of the learning domains is effective and successful using VR in boosting students' creativity. The literature shows the effectiveness, utility and prevalence of cognitive domains. VR improves students' comprehension and learning performance. Students get a deeper understanding of their design concepts and solutions. The potential of VR has been demonstrated, but it needs to be seen how and also where such capabilities may be effectively utilised to architecture education. This study will pave the way for further investigation into the implementation of immersive VR technologies and their application to design studio.

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